Screening of Quantum Cutting Systems Time-Resolved Photoluminescent Spectroscopy

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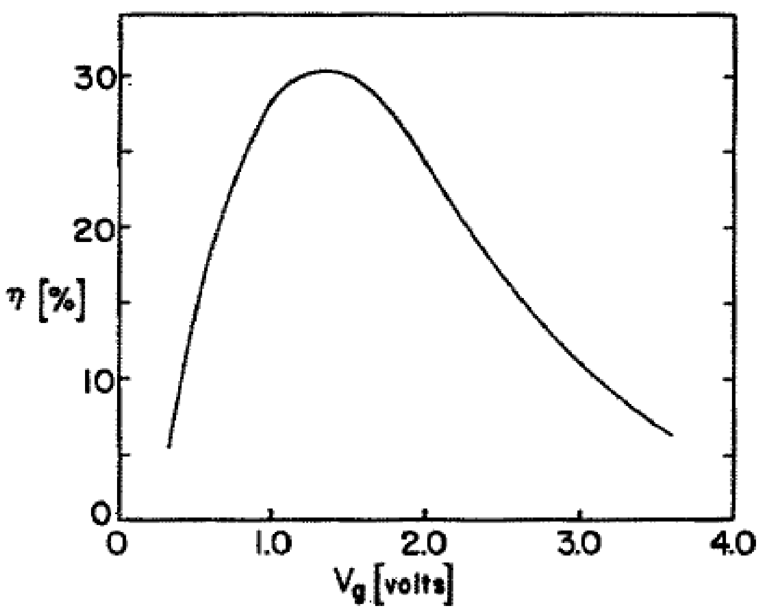
Fundamentals and Applications of Spectroscopy

Background

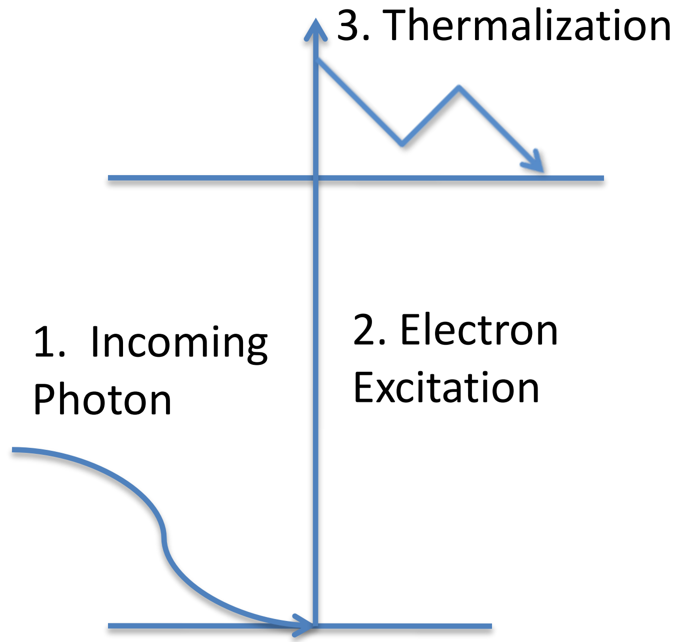
Solar energy is the best candidate for solving the worlds energy needs.

Efficiency is lost due to photon thermalization.

Efficiency cannot be better than 31% using conventional single-junction solar technology.



Shockley, Queisser. *Detailed Balance Limit of Efficiency of p-n Junction Solar Cells.* J. App Phys. V:32 N:3, 1961.



Concept

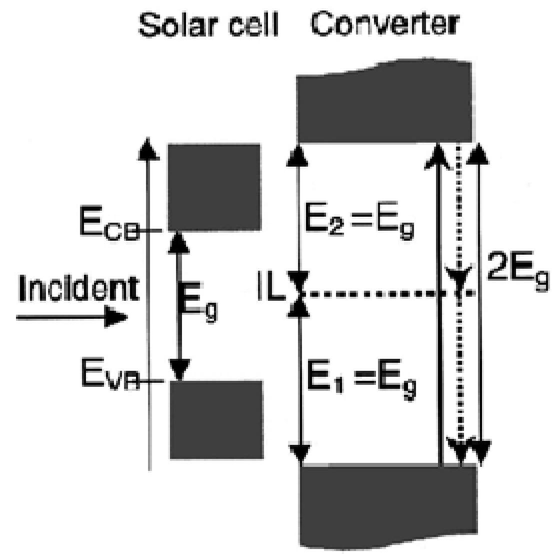
Actinides used for fluorescent lamps, displays to convert Hg / Xe UV emission to red, green, blue

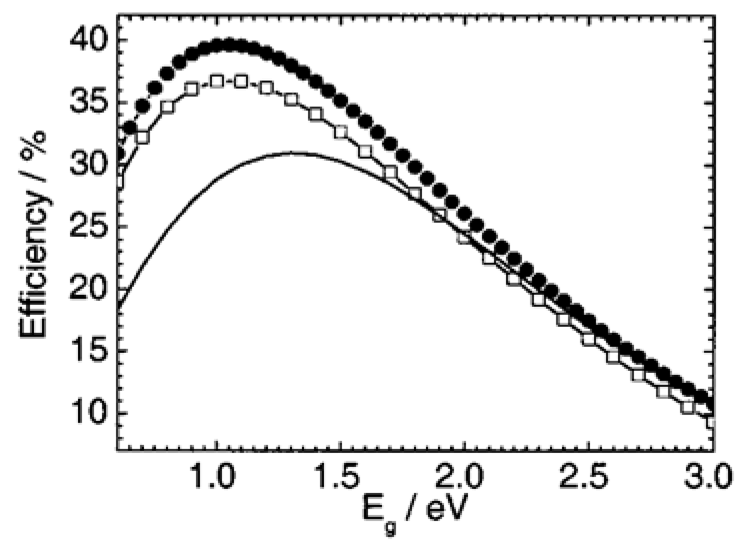
If $E_{hv} > 2E_g$, could produce more than lower energy photon

Could be applied to solar cells, reduce losses from thermalization

Optimum efficiency increases vs. Shockley-Queisser limit, shifts to lower band gap, Eg ~1.1 eV

Can use Si semiconductor, engineer fluorophore





Trupke, et al. *Improving solar cell efficiencies by down-conversion of high-energy photons.* J. App Phys. V:92 N:3, 2002.

Area of Investigation

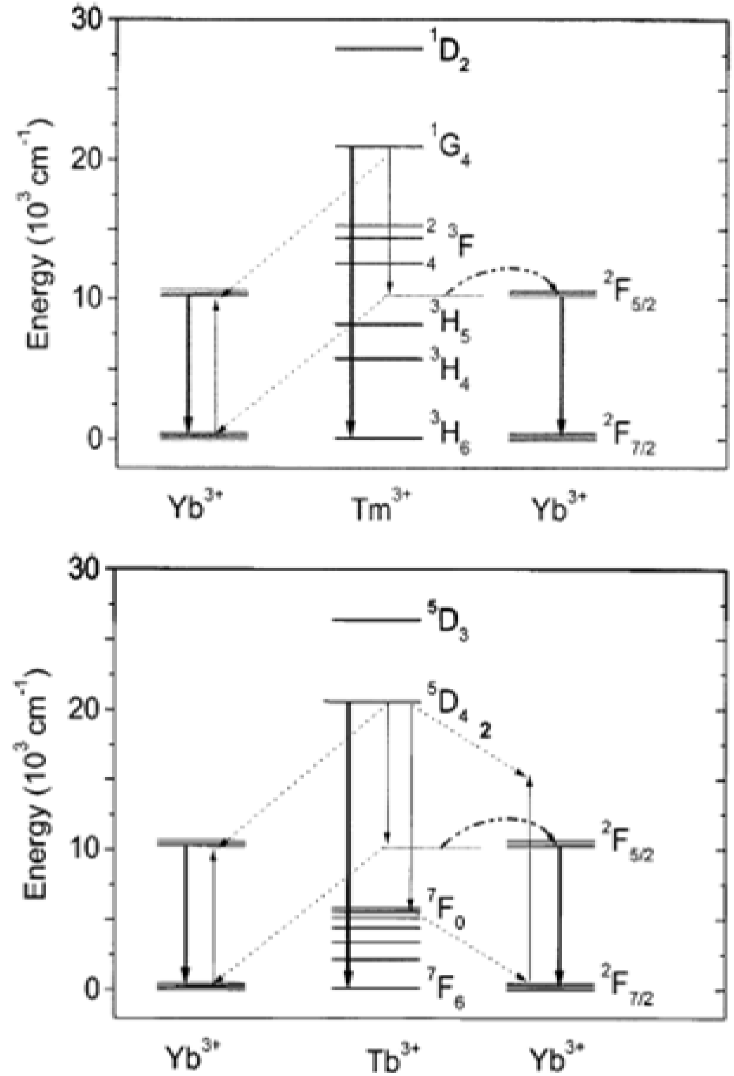
Actinides have screening from 5p, 5s orbitals. 4f levels evaluated by Dieke.

Yb^{3+} optimal for ~1.1eV emission, Tm^{3+}, Tb^{3+} effective for ~2E_g absorption

Energy transfer depends on distance of ions

Non-radiative relaxation depends on glass lattice used (e.g. borate vs. iodide)

Will explore materials using photoluminescent spectroscopy



Richards, B.S. *Luminescent layers for enhanced silicon solar cell performance: Down-conversion.* Solar Energy Materials & Solar Cells. V:90, 2006.

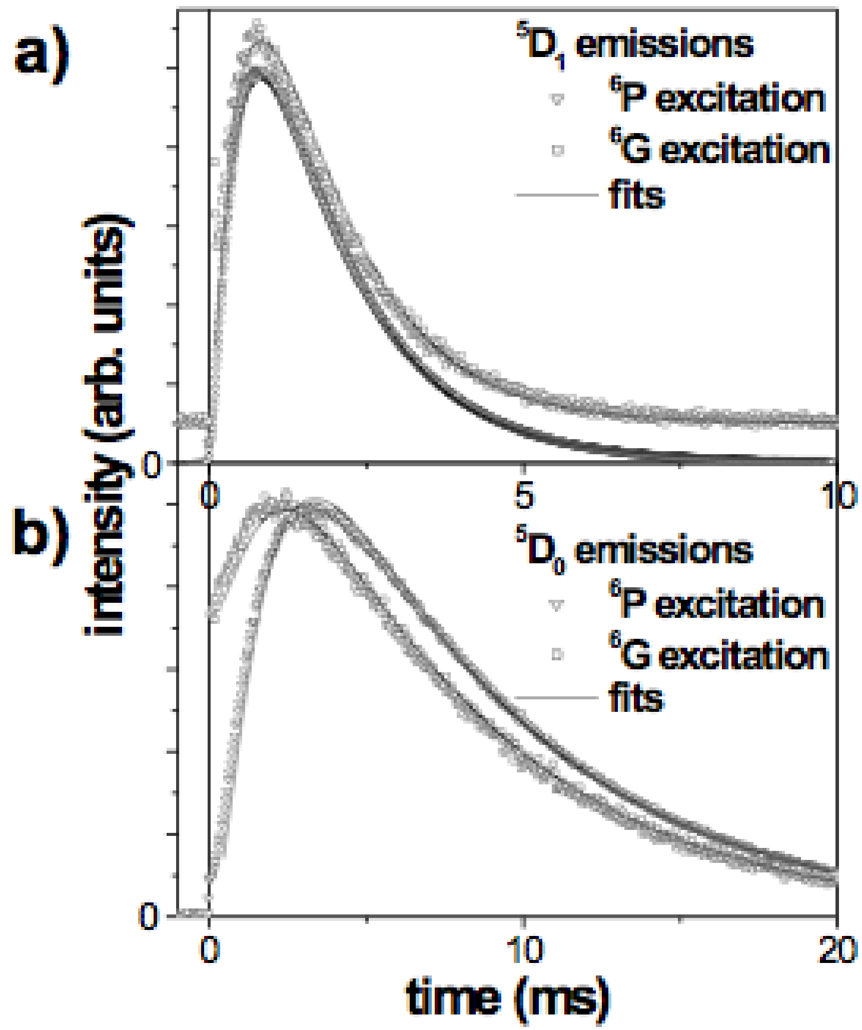
Expected form of Spectrum

Simple fitting of the curve should correspond to the kinetic model below.

$$\frac{dn_P}{dt} = [-\gamma_P n_u - \gamma_P']n_P$$

$$\frac{dn_1}{dt} = \gamma_P n_P n_u - \gamma_1 n_1$$

$$Criterion: \frac{\gamma_P n_u}{\gamma_P'} > 19$$



Vergeer, et. al. *Luminescence spectroscopy of quantum cutting phosphors: materials, measurements and mechanisms*, 2005.

Analysis, Reapplication, and Conclusions

- Figure of merit: $M=N_{Cl} \cdot (1-f_{emitter}) \cdot o$
- Compares maximum absorption per thickness for different materials
- Best materials would be developed further